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FATIGUE AND STRESS IN WILD AND DOMESTIC RATS.

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## FATIGUE AND STRESS IN WILD AND DOMESTIC RATS.

### An Abstract.

The most significant findings previously reported in an interim report are summarized.

Special note is taken of additional findings since the time of the interim report bearing on the occurrence of "psychological" fatigue or "emotionally" induced convulsions among both wild and domestic animals which are interpreted as substantiating our hypothesis that the treadmill used to induce fatigue in rats constitutes a stressful situation which induces psychological fatigue attended by convulsions in some animals.

Instances of breakdowns in the form of convulsive seizures found among some of the domestic subjects have been tentatively classed as conditioned breakdowns, since they occur during the transfer of the animals from a carrying cage to the treadmill, as well as in the treadmill prior to actually starting this fatigue device.

The importance of the findings described above is mentioned as meriting further study from both practical and theoretical viewpoints.

Further results on a pilot study reported in the interim report relative to the influence of a goal object on increasing resistance of both wild and domestic rats to the onset of fatigue are described. The effects of an early stressful environment on increasing treadmill stamina of both wild and domestic rats are mentioned.

A current experiment concerning the effects of conditioned fear responses on treadmill stamina, and or/ effects of treadmill running on ease and persistence of a conditioned fear response is described.

## FATIGUE AND STRESS IN WILD AND DOMESTIC RATS.

An interim report and request for continuation and extension of this research program, dated January 3, 1953, described in detail the nature of the problems studied, apparatuses used, subjects, and the results of the studies to the above date. This report will be restricted to an overall summary of our findings plus somewhat more detailed report on those aspects of the experiments not completed at the time of the interim report.

Using laboratory constructed treadmills as a method of inducing fatigue in 30 domestic and 25 recently trapped wild Norway rats, we have found that the latter animals are better able to withstand fatigue than the former. Using running times, number of revolutions of the plastic endless belt, number of "backslides" while running, and number of contacts with the electric plates, as criteria of the stamina of the subjects on the mills, results in favor of greater stamina of the wilds were statistically significant beyond the 1% level of confidence. We have described individual differences which exist among the animals of both the wild and domestic groups relative to "adaptability" to mill running. It appears that subjection of rats to the treadmill is itself a stressful experience. Some animals adapt well and run continuously until collapse from exhaustion. Others adapt poorly or not at all. The behavior of this latter group is characterized by a high degree of emotionality manifesting itself through excessive teeth chattering, urination, defecation, and most strikingly in the occurrence of complete pattern convulsions. This group of subjects we have termed "non-adapters" and have emphasized in previous reports that this finding may prove to be of considerable practical and theoretical importance. Firstly, because search of the literature failed to reveal production of breakdowns in the form of convulsions in the absence of either sound or electric shock; secondly, because since the writing of the interim report additional results are available strengthening our hypothesis that these breakdowns are "emotional" or "psychological" in nature and may

open the way for studies on psychological vs. physiological fatigue which we suggested in the former report. In addition to our previous reported finding that seizures would occur repeatedly on exposure to the mill when the electric spark used to motivate running was not in operation, we have recently obtained evidence that this type of seizure may be conditioned. With four out of nine domestic animals classed as poor adapters and showing the "emotional" seizures we observed spontaneous seizures in the carrying cages when we attempted to introduce the subjects into the mill from the carrying cages. No such spontaneous seizures have been observed to date in the laboratory. A total of 15 exposures to the treadmill situation resulted in 100% seizures of the "emotional" type following 25 seconds of mill running in these "non-adapters". The spontaneous seizures, which we shall tentatively call conditioned seizures, occurred during the last 7 introductions to the mill. To date, although as previously reported, poor adapters were found among the wild group on the treadmill, with occurrence of "psychological" seizures, none of these subjects have exhibited the conditioned phenomenon described.

The pilot study described in the interim report on swimming rats in an inverted bell jar to determine the effects of the presence of a goal object on speed of fatigue onset has been continued with the addition of more subjects. An inverted glass bell jar previously described has been used to swim wild and domestic Norway rats to exhaustion. It was found that 10 domestic rats averaging 185 gms. body weight were able to swim for an average of  $2\frac{1}{2}$  hours prior to exhaustion. A similar number of like weight wild animals were able to swim for a mean period of 5 hours before exhaustion. Subjects were swum daily in the bell jar for a period of one week in order to determine the average swimming time prior to distress for all animals. The animals were then taught to escape via a float-ladder device affixed to

the side of the bell jar over a wide black adhesive tape. After the habit was mastered by all subjects through alternate day trials over a period of 14 days, rats in both domestic and wild groups were again swum daily for a 10 day period with only the ~~black~~ black tape present marking the locale of the float-ladder. The escape device itself was removed during these trials. We found that the rats in both groups increased their swimming times prior to exhaustion in the presence of the symbolic goal object. Specifically, the domestics increased their average swimming times from  $2\frac{1}{2}$  hours with no goal object to 4 hours with the symbolic goal; wilds increased their mean swimming times from 5 hours to  $9\frac{1}{2}$  hours. These differences have been found to be statistically significant.

At the time of writing the interim report we reported results on 3 domestics and 3 wilds reared from weaning to 60 days of age in the previously described stress box and subsequently tested on the treadmill for fatigue resistance. The preliminary results have been strengthened by the finding that 12 additional animals ( 6 domestics and 6 wilds) reared in the stress box show greater resistance to treadmill fatigue than animals not so reared. The domestics were able to run the mill for an average of 15 hours before signs of exhaustion; no upper limit could be determined for the wild subjects reared in the stress box and exposed during adulthood to the mill. Some of these subjects ran as long as 18 hours without signs of serious distress.

It seems worthy of special note in connection with our application to continue these studies, that stress box reared animals were all mill "adapters" none of them showing the previously described "psychological" fatigue or emotionally induced convulsions.

In our interim report we mentioned the fact that due to unavoidable delay in obtaining a suitable recording device we were unable to proceed with an experiment designed to determine the effect of a conditioned emotional response on treadmill fatigue and/or the effect of treadmill fatigue on the ease and per-

sistence of a conditioned fear response. We have now completed construction of the conditioning apparatus and designed the method to be used in testing the conditioned fear through use of the startle pattern. Our apparatus and experimental design is based on the article "Conditioned Fear as related to the Magnitude of the Startle Response to Auditory Stimulation" by Brown, Kalish, and Farber, which appeared in the Journal of Experimental Psychology, 1951, 41, 317-328. In place of the mechanical method of recording we have instituted a more accurate electric method. Results of the experiment are not yet available as the study is still in progress.

We plan for the future, contingent upon favorable action on our previous request, to continue and broaden our studies along the lines outlined in part 2 of the interim report, and suggested by the results reported in this paper.

REPORT ON THE ANATOMICAL COMPARISON OF ADRENAL  
GLANDS OF WILD AND DOMESTICATED RATS FOLLOW-  
ING SUBJECTION TO STRESS SITUATIONS.

Material and Methods.

In this study a total of 39 rats were used. Of these 21 were domestics, and 18 wilds. Both the left and right suprarenals were removed immediately after death. The removed glands were fixed in Bouin's fluid and weighed on a chainweight balance to the nearest tenth of a milligram after fixation. They were then run up into paraffin and after sectioning, at 20 microns, and staining with hematoxin and eosin, every fifth section was projected and drawn upon "Permanized Artesian Bond" paper. The method used for the volumetric determinations was a modified procedure employed by Jackson(1919).

Of the specimens studied both histologically and volumetrically 29 pairs of suprarenals were from rats run on the treadmill; the remaining pairs were from normal rats taken at random from the colony.

Results.

From the volumetric determinations of the ratio of the medulla to the cortex it was found that there was no statistically significant differences between the normals and the animals subjected to stress. The greatest discrepancy in adrenal size is confined entirely to the cortex. There is little or no change in the amount of medullary tissue. The difference in the size of the glands taken from the domestic and wild rats agreed with results as found by Rogers and Richter(1948).

Histological studies showed the wild Norways to have a thicker zona fasciculata and ~~reticularis~~ than the domestics. The only histological difference found

between the controls and the stress groups was in the blood supply of the medulla. The capillaries in the medulla anastomose and run in all directions. They are wider than in the cortex, can properly be termed sinusoids and are drained by thin walled nevules.

With only two exceptions the stress group was found to have abnormal distention or dilation of the medullary sinusoids. This dilation was found in varying degrees. Rats that had run for a long time or died on the treadmill showed extreme dilation; rats run for shorter periods showed correspondingly less. The recently discovered occurrence of "psychological fatigue" or "emotional" convulsions reported by the principal investigator to occur in some animals on the treadmill has not yet been checked adrenally. The dilation difference mentioned above was more marked in the domestics than the wilds.

From the observations of Hartman, Waite and Powell, occlusion of the veins might cause blood to permeate the cortex, thus directly influencing its activity. The possibility of occlusion of the out flow from the adrenals for a short time, and then a sudden release was indicated. They found that although cats usually gave evidence (dilation of the deganglionated iris) of increased epinephrine output soon after they start exercise on a treadmill occasionally there was considerable delay, ended by sudden dilation of the iris to the maximum. The sudden dilation was accompanied by convulsions. This could be due to an accumulation of epinephrine held back by contracted venous muscles, whose release later flooded the organism with epinephrine.

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